AUTOMATIC DATA PROCESSING AND NAVAL HOSPITALS

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AUTOMATIC DATA PROCESSING
and
NAVAL HOSPITALS

by

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PREFACE

Using outmoded equipment and hampered by lack of trained personnel, naval hospitals have managed to put together a tight, well integrated system of punched card data processing over the past three years.

The program began with a pilot study in payroll and accrual accounting published in 1961 by the U. S. Naval Hospital, Portsmouth, Virginia, from there, it has spread to all naval hospitals and includes all types of data from accounting data to medical research data to workload scheduling and control data.

But despite very substantial progress, naval hospitals have barely scratched the surface of the potential offered by computers. The naval hospital of the future must be prepared to acquire and use computerized information systems if it is to survive the new knowledge and information being generated in the "information explosion" of today.

The purpose in writing this paper is to trace the development of the data processing program in naval hospitals, and to make an estimate of future developments.

Material for the paper was obtained from the Data Processing Division, Bureau of Medicine and Surgery, Navy Department, Washington, D.C., from the Systems Development Corporation,

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Washington Branch, 5821 Columbia Pike, Falls Church, Virginia, and from a survey of current books and periodical literature on the subject of medical data processing.

I especially wish to thank CDR Forbes H. Smith, MSC, USN, of the Navy Department, Bureau of Medicine and Surgery, and Mr. Sam Hollen of the Systems Development Corporation for their assistance in developing this paper. I also wish to thank the personnel of the National Library of Medicine, Washington, D.C. for their help in locating source material, and my wife Delfina for her help in editing and typing the final copy.

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INTRODUCTION

The visible and usable parts of the body of information generated to support and advance medical science represents only about one-tenth of that available. And even though this small portion is used, it is quite often poorly used and not related to other bodies of information equally available. The medical profession has been attempting to use manual methods to give up-to-date answers to its data processing problems. It has been unable to accomplish these answers rapidly enough to keep pace with the advances in technology that have occurred since World War II. One group put it this way:[1]

> Present methods offer little hope of dealing adequately with the accumulating mass of clinical records, the mounting volume of documentation, and the increasing weight of research data (in the medical profession).

This paper is a description of one approach to the problem of data processing in the medical profession. It describes a data processing system that could be used by a naval hospital of the 1980's and compares this system with the one currently being used in naval hospitals.

By way of history, the current system began with a pilot project at the U.S. Naval Hospital, Portsmouth, Virginia, and from there has spread to all naval hospitals. It presently

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[1] Chas. J. Roach, Myrvin H. Ellestad, M.D., and Raymond B. Lake, "Medical Data Processing and Computer Automated Hospitals," Datamation, June 1962, p.25.

includes all types of data being generated in volume, from accounting data, to medical research data, to workload scheduling and control data. It all began using punched card tabulating equipment, but, over the recent past, has come to include several small scale punch card computers and two IBM type 1620 digital computers.

The program shows potential even in its present form. But as the value of the system becomes more firmly established and as the cost of large scale computers begins to drop, the program will undoubtedly become re-oriented to large scale digital computers.

As anyone familiar with the subject knows, there are as many predictions of the potential role of computers in our society as there are authors who write about computers. These predictions range from one extreme which has computers taking over decisions, learning functions, and thinking functions, to the other extreme which describes computers simply as high speed morons capable only of manipulating symbols. This paper tends toward the latter extreme, and is deliberately confined to developments which are possible within the present state of computer technology.

In making this estimate of the data processing system for a naval hospital of 1980, the only assumption made here is that attempts to solve the problems in data processing in naval hospitals will continue at about the same rate as at present.

CHAPTER I

A LOOK TO THE FUTURE

Perhaps the best way to begin a discussion of the system for data processing in the naval hospital of 1980 is to describe one of the problems that currently requires solution in naval hospitals of today.

Since the beginning of World War II, the number of drugs in use in the medical profession has multiplied enormously. A whole new series of antibiotics, hormones, tranquilizers, analgesics, and other preparations has been developed to take the place of older drugs. To compound the problem, each manufacturer of drugs puts out identical preparations under different trade names or mixes several preparations into compounds which he markets in various forms under different names.

However, before a physician can use a drug he must know the properties of the drug, its therapeutic effects and side effects, its dosage, and the form in which he intends to have it administered. To memorize all of this information is near impossible task so he tends to rely on certain drugs and on the information he receives about new drugs from salesmen and from the hospital pharmacist. Some of this information is reliable, some is definitely biased or incomplete.

Let us place this doctor in our hospital of 1980 and see what happens.

First he interviews patient X and determines that X needs an antibiotic to combat the effects of an infection caused by a particular bacteria. The doctor goes to an electric typwriter in his office, which is connected to a large random access computer located at some remote point in the building. He types a few letters in code to identify himself, he types the hospital register number of his patient, and he types a symbol into the computer to identify what follows as an order for medication. He then types the order which might read something like this "Give 500 mg tetracycline q 6 h for 6 days."

The computer receives the message and performs a "table look-up" routine in which it compares the dosage ordered against a table of normal dosages for the drug. If the dosage is within these limits, the computer goes on to the next function; if not, the computer sends a message back to the doctor's typewriter that says, "Please recheck dosage."[1]

Assuming that the dosage is correct, the computer checks the clinical record of patient X to determine whether it contains any notation of adverse effects from previous administrations of the same drug. If the record contains an adverse notation, the computer sends the message "Please check patient X for sensitivity to tetracycline." If the record is clear, the computer goes on to the next function which is to send the

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[1] Jordan J. Baruch, Sc. D., "Hospital Research and Administration with a Digital Computer," Circulation Research, 11:3, p. 629 (1963)

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medication order to the Pharmacy.

At the Pharmacy, a typewriter similar to the one used by the doctor, and also interconnected to the computer, receives a message in the form of a medication label which reads, "1-6-80, Patient X, Ward Y, Rx, Tetracycline. Two tablets every six hours beginning 1200 hours on 1-6-80 till 0600 hours on 1-12-80; Dr. Z." This same message is printed out on a similar typewriter located at the nurse's station on ward Y.

The Pharmacist counts out the appropriate number of tablets, places them in a bottle, affixes the label printed by the computer, and dispatches them to ward Y via dumbwaiter. Meanwhile, the computer has subtracted the amount of tetracycline dispensed from the inventory of tetracycline normally carried on hand in the Pharmacy, and, if the amount on hand has fallen below the safety level of that drug, has entered into a program which will cause a requisition for more tetracycline to be printed on a typewriter in the Hospital Supply Office. As an alternative, the computer can retain and sort this requisition into a group with others held for the Pharmacy and print out all requisitions for the Pharmacy in the Supply Office at some scheduled time.

At the same time, the computer enters Patient X's chart and records the medication order, it stores the order in memory so that every six hours for the next six days it can remind the nurse on ward Y that patient X, and any other patients involved on that ward, have medications due them.

At the same time, the computer extracts workload data from the transaction and records it against figures maintained

for the Pharmacy and for Ward Y.

How much time has all this taken? About as much time as is necessary for the typewriter carriage in the doctors office to return to a ready position and receive the message, "Medication O.K." from the computer.[1] And herein lies the seeming magic of the computer. It can handle data at extremely high speeds, make its computations and manipulations, and return relatively unsophisticated answers (such as those involved in our problem) between movements of the carriage on its typewriter output device.

To carry our problem further, the computer can, at the time it transmits the Pharmacy requisitions to Hospital Supply, check the inventory levels in the Supply warehouse and update them for issues made to the Pharmacy or to any other unit involved in drawing supplies on that date. It can record the cost of the supplies issued against the appropriate departmental account and subtract this amount from the operating funds of the hospital. It can maintain inventory records by any classification, financial or otherwise, that is desired. And it can print inventory or accounting summaries on a signal from the remote typewriter station in the Fiscal and Supply Office.
If the inventory level falls below a predetermined minimum, the computer can link itself with a computer in the nearest supply point and print out a requisition for supplies to replenish the warehouse stock. At the same time, it can account for the Navy Stock Fund money involved, print out a receiving record in the

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[1] Ibid.

Supply warehouse, and collect workload data for the transaction as it pertains to the departments involved. It can furnish immediate status information on funds and on inventories on demand. If the material involved is available only on the open market, the computer can determine a source and print out a purchase order specifying the most economical quantity and supplier.

If the doctor is in doubt as to the availability of a particular drug, or wants an unnamed drug that will produce a particular therapeutic effect, he can make an inquiry from his typewriter station and receive a list of the drugs carried in the Pharmacy having the therapeutic effect desired, or a list of similar drugs carried that bear different names, forms, or dosages from those requested by the doctor. Of course the computer does not originate this information. It must be made available and kept current by the people who program and operate the data system.

If the nurse supervisor coming on shift desires status information on the patients for whom she will be responsible, she can obtain a typewritten abstract of all nursing notes that have been recorded for her patients during the last shift, including medications given, estimated condition of her patients, medications and treatments due on her shift, unusual temperatures or other vital signs recorded, or any other information normally recorded in a patient's clinical chart. After she has finished reviewing the condition of her patients she simply throws away

the abstracts, for they are available for immediate access in the computer to anyone who has a need for them. This same information is available to the doctor on his morning rounds or to the Chief of a Service who desires information on a particular patient. The security of this information is not in any more jeopardy than at present since the output typewriters are located only in controlled areas such as nurse's stations or doctors offices where the patient's clinical charts are presently stored. Personnel in administrative areas of the hospital could be allowed only limited access to patient information by proper programming and the same access could be allowed personnel in professional areas to administrative information if desired.

Let us now take an overall look at this naval hospital of the 1980's.

The Hospital Will be constructed so as to take advantage of modern building materials and techniques. It will be built of aluminum or steel with great expanses of glass on the exterior walls to permit the sun into its rooms. The shape of the building will be dictated by the need to centralize communications, data processing, and the many services ancillary to care of patients; therefore, the hospital will probably be built in a circular,[1] or pentagonal shape with elevators, dumbwaiters, communications linkages, test and research equipment, operating rooms, laboratories, X Ray facilities, and all of the other ancillary services located in the central core.

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[1] Jane Barton, "Electronics is Changing the Structure of Hospitals and Medical Care," The Modern Hospital, June 1960 p. 81.

The periphery of the building will be occupied by patient's rooms open to the sun. The environment of the rooms will be controlled completely by automatic controls that will permit the filtration of air and will permit the introduction of oxygen or other therapeutic gasses to the rooms. Some of the rooms will be equipped to permit the reduction or increase of atmospheric pressure as necessary to the comfort or treatment of the patient; some of the rooms will be equipped to permit the intruduction of aerosol sprays. The rooms will be smaller, less cluttered with equipment, and may even be built with pre-moulded plastic walls which would incorporate bathroom fixtures, utility outlets, and perhaps even beds in their pre-moulded sections. Because of the type of construction used, the cost per bed, including the vast array of electronic devices throughout the hospital will perhaps be lower than at present.[1]

The hospital will be divided into an intensive care section, a convalescent section, and an outpatient section rather than into separate units by medical specialty. This will provide the patient with a proper degree of care based on his overall condition rather than on the somewhat artificial criteria of type of medical problem involved.[2]

In the intensive care unit, each patient will be under constant monitoring by electronic devices. Physiological transducers will record temperature, pulse, respiration, blood pressure,

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[1] Ibid.

[2] Chas. D. Flagle, "Operations Research in the Health Services," Circulation Research, 11:3, p.621 (1963)

and electrocardiogram on tapes monitored at the nurse's station.[1] These tapes will be fed into the hospital computer where they will be converted to digital symbols and compared with a so called "programmed normal" which will cause a warning message to be printed out at the nurse's station in the event there is any significant deviation from the normal. Meanwhile, any siginificant deviations from the normal will be recorded in the patient's clinical record in computer memory whenever they occur. These recordings will be immediately available for review by the doctor or specialist attending the patient.

The convalescent section will be located in the upper levels of the building where the patients will be permitted to care for themselves to a considerable degree. This section may be further subdivided by medical specialty where this enhances the treatment possibilities, but care here will be geared to returning the patient to complete health rather than to providing constant hospital care.

The outpatient section will be located on one of the lower levels adjacent to the emergency rooms. It will be equipped to provide rapid one-stop service for ordinary visits, but will be tied to the hospital computer for more extensive services and for recording of patient data. Scheduling and data collection will be under the control of the computer as will workload information, medication requests, supplies requests, and accounting.

The outpatient section will be larger, more extensively

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[1] Barton, op.cit.

equipped, and more extensively staffed than our present outpatient units. It will be the center of the medical and dental activities for the naval community which it serves, and its expanded facilities will permit the reduction of dispensary and sick call services at other locations in the community. Initial contact with the patient may well be made by videophone[1] from some outlying station, and the examining doctor may give treatment instructions to a hospital corpsman located at the distant station if the patient obviously does not require his personal attention. In the event the patient must come in to the hospital, he can be brought in by helicopter or other rapid transportation methods. In any event, the outpatient section will assume a much greater importance and will become a more integrated part of the naval hospital of the future.

The inpatient sections of the hospital will be smaller than is now considered acceptable; that is, the ratio of beds to total population served will be lower. Since the hospital will be able to accept, treat, and release a patient in a shorter time than is now possible, and, since a greater proportion of the patients will be treated as outpatients, the need for beds will be correspondingly dimished. The hospital will be built as a dynamic, short term treatment center with a preponderance of facilities for outpatients and intensive care patients, and with fewer facilities for convalescent patients.[2]

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[1] E. Todd Wheeler, "Technology will Shrink Size of Hospitals," The modern Hospital, September, 1963, p.159.

[2] Ibid.

Food preparation and service for the hospital will be carried out in a central kitchen located on one of the lower levels and will consist of a cafeteria for the staff and convalescent patients, and a delivery service via dumwaiter for the intensive care patients. The latest automated equipment will be available in both the preparation and service sections. Menu selection and integration, provisions inventory control, accounting, scheduling, workload summary and programming of certain of the food preparation equipments will be under the control of the hospital computer.

Laundry service, using automated wahing, tumbling, drying, and ironing equipment, will be located in one of the basement areas of the hospital. Linen delivery will be handled via dumbwaiter. Orders for linen, linen inventory, workload scheduling and workload data will be handled by the hospital computer.

A working stock of medical supplies will be located in another of the basement areas, accessible to the operating section of the hospital via dumbwaiter. Again, orders for supplies, inventory control, accounting, workload scheduling, and workload summary will be under the control of the hospital computer.

Bulk stocks of supplies will be stored under automated warehouse conditions at some remote point to be used as back up stock for the supply room in the main building. Stock locations and rewarehousing will be programmed into the computer so that the location and quantities of stock will be known at all times. As mentioned previously, stock replenishment will be controlled by the computer, and stock receipts and issue data will

be fed into the computer to update the inventory control records.

Located on the top level of the building will be a central monitoring station that will collect key operating data from the physical plant and incorporate remote control devices to supervise the operation of the electrical, steam, water, and compressed air distribution systems.[1] This station will automatically maintain the environment inside the hospital building in its proper equilibrium and will report to the maintenance shops via the hospital computer whenever any of the systems deviate from a preset normal. The station will meter the use of utilities and feed these data to the central computer for updating of the records in memory. It will report on an exception basis to the Maintenance Division any unusual deviations from normal use of utilities by the operating departments of the hospital.

The maintenance shops themselves will be located in a separate building from the main hospital. Work will be planned, scheduled, estimated, accounted for, and controlled by means of data fed into the hospital computer. Trouble calls will be received via the computer from the hospital to the input typewriter located in the maintenance building.

Each of the ancillary services, the X Ray Department, the laboratory, the central surgical supply room, the operating rooms, the physical therapy department, and the many clinics and adjunct services, will be connected to the hospital computer for workload

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[1] Chas. S. Eckler, "Potentials of a Master Control Center," Hospitals, March 1, 1962, p.85.

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scheduling, accounting, supply orders, linen orders, maintenance trouble calls, patient data collection and any special purpose applications such as electrocardiographic interpretations[1] or diagnostic interpretation of symptoms.[2]

From this system, then, emerges an efficient time saving method of dealing with the thousands of individual events that occur within a hospital each day. The computer serves as a data integrator and message center for the hospital. It routes each of the messages received from its many remote input stations to the proper output station, to its memory, or to a regional computer responsible for collecting given types of data from all hospitals in the area.[3] The information stored within the computer memory is immediately available to each person in the hospital who should properly have access to it, and can be protected from improper access by adequate programming. But the computer is much more than a communications switchboard and data collector as will be seen later.

To assist in visualizing the function of the data processing system in helping care for patients, let us follow a typical patient through a course of treatment in the naval hospital of 1980.

He is first seen on videophone in response to a call he has

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[1] Hubert V. Pipberger, M.D., "Use of Computers in Interpretation of Electrocardiograms," Circulation Research, 11:3, p.555 (1963).

[2] Cesar A. Caceres, M.D., Integration of Data in Diagnosis," Circulation Research, 11:3, p.563, (1963).

[3] Baruch, op.cit.

placed to the outpatient section of the hospital.[1] The doctor who examined him on the videophone decides that because of the apparent seriousness of his condition he should be seen in person. Meanwhile, the doctor asks the hospital corpsman in attendance to obtain the patient's previous medical records.

The corpsman types a code into the electric typewriter input station which alerts the computer to the fact that the information which follows is a request for medical records. He then types the patient's name, date of birth, and service number into the computer and the computer searches its memory for the patient's health record. If it is available in memory, the computer immediately types the record out on the electric typewriter;[2] if it is not available, the computer switches the request to a computer at the Bureau of Medicine and Surgery which conducts a search and returns the record to the hospital computer. At the hospital, the health record is recorded on tape and simultaneously printed out at the typewriter in the outpatient section. The doctor reviews the record and extracts portions of it which he instructs the corpsman to feed back to the computer for later use in diagnosis. In addition, he finds that the patient is due to receive certain immunizations, and this he instructs the corpsman to feed into the computer for later retrieval when the patient is ready for discharge.

By this time, the patient has arrived, and, after a brief

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[1] Wheeler, op.cit.

[2] Baruch, op.cit.

examination to insure that he has no emergency complaints, the doctor directs the patient to an examining room.

Inside the examining room is a television screen on which is displayed a series of questions similar to those used in the Cornell Medical Index-Health Questionnaire.[1]

The patient is given a board containing two buttons and asked to press the correct button to indicate a yes or no response to the questions displayed, depending on whether he has or has not experienced the symptoms described in the question. The entire procedure is controlled by the hospital computer, and each time the patient indicates a response it is recorded in memory. As the responses begin to localize the patient's complaints to a specific diagnostic area, the computer selects more specific questions until all potential diagnostic areas have been explored in a general way and each area where the patient has specific complaints has been explored in detail. Upon completion of the questioning, the computer compares the patient's responses with various symptom patterns that it holds in memory and prints out a correlation of these comparisons showing the most likely diseases and their relative probability.[2] The computer also suggests additional tests or examinations that might be performed

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[1] See Appendix for an example of this questionnaire. For a more complete description of its use, see the article by Keeve Broadman, M.D., el al., "Interpretation of Symptoms with a Data Processing Machine," Archives of Internal Medicine, Vol.103, p.776, May 1959.

[2] Caceres, op.cit.

to confirm the presence of one or more of the diseases indicated.[1]

The patient is sent to the Admissions section of the outpatient clinic and his previous medical record is updated by the corpsman performing the admitting function. In doing this, the patient's previous identifying data is reviewed and current address, current next of kin, current duty station, and so forth, are typed into computer memory in place of the previous information stored there. Meanwhile, the computer has already updated the record with current complaints and tentative diagnosis, and assigned the patient to a ward based on the doctors estimate of his condition and the availability of beds.

The patient is sent to the ward to be placed in bed, meanwhile, the admitting corpsman instructs the computer to print out the patient's current medical record for the ward nurse to review.

While this is taking place, the admitting doctor has fed into the computer his directions to the laboratory for various tests to be performed, to the Pharmacy for medications required, to the food service for diet required, to any clinics involved for special examinations, tests, or treatments required, and to the nurse's station for instructions in nursing care required. Each of these instructions is scheduled where necessary by the computer, and routed to the unit that is responsible for follow up action. At the same time, the computer records the orders in

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[1] David M. Cleary, "The Role of Automation in Diagnostics," Current Medical Digest, April, 1959, p.57.

the patient's now current clinical chart.[1]

As the tests and examinations are performed they are acknowledged to the computer by the unit performing the work and the results are fed in for updating the patient's record and for transmission to the doctor.

In the case of laboratory or EKG examinations, the tests are performed on direct reading analog instruments that transmit the results to the computer for conversion to digital form and subsequent recording and print out at the doctor's office.[2]

By the time the initial orders are complete and the patient's record has been updated with the results of the various tests and examinations performed, the doctor is able to obtain from the computer a firm diagnosis which he can evaluate in the light of his own knowledge. He can either confirm the diagnosis or continue his investigation.

In the event that he wishes further information on a particular diagnosis, he can signal the hospital computer to send him an abstract of current literature on the disease in question. The computer will link itself to a regional computer such as the one located at the National Library of Medicine and return to the doctor a brief summary of each of the current references available on that disease. After reading the summaries, the doctor can

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[1] Charles J. Roach, Myrvin H. Ellestad, M.D., and Raymond B. Lake, Medical Data Processing and Computer Automated Hospitals," Datamation, June 1962, p.25.

[2] Margaret E. Grisby, M.D., William H. Bullock, M.D., and Milton Fuertes, M.D., "Paper Electrophoresis of Serum Proteins," Archives of Internal Medicine, November, 1962.

request complete print outs of the references from the regional computer if he desires to do so.[1]

Once the doctor has satisfied himself that the diagnosis is accurate, he can receive assistance from the computer in formulating a course of therapy. The computer can be linked with a regional computer center with a memory bank of thousands of case histories from which it can select those histories which most closely parallel the history of the present patient. These histories would be selected by an electronic correlation of pertinent portions of the patient's current medical history transmitted under program control by the hospital's computer and matched with histories on file at the regional center. From the case histories received, the doctor can decide upon a course of therapy or he can discard the data and use other methods to arrive at a course of therapy.

Up to this point, we have been discussing evolutions in patient care that normally take days or weeks of the patient's time, the doctor's time, and the time of the nurse, hospital corpsmen, and other people involved in the case. With the help of the computer, these same problems could be solved in a matter of hours after the initial contact with the patient, or, in a complicated case, within the first day or so of hospitalization.

The instantaneous communication provided by the computer, along with the optimum scheduling of tests and examinations, the instantaneous feedback of results, the lack of necessity to

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[1] Lee B. Lusted, M.D., "Application of Computers in Diagnosis," Circulation Research, 11:3, p.599 (1963).

record written notes and descriptions, the instant access to files of patient data, research data, case history data, medical literature data, drug therapy data, and diagnostic data, all give the doctor a considerable relief from routine work so that he can be alert to the more important aspects of treatment. And, incidentally, all these factors contribute toward shortening the patient's stay in the hospital. So our computer has become an extremely important and versatile assistant to the doctor in treating his patient.

But our patient is still being assisted by the computer in less direct ways. Services that the computer can perform indirectly are:

1. To assist the physician in integrating medical literature, medical records, hospital management information, and diagnostic information into sensible patterns that assist him in treating his patient.

2. To provide the doctor with immediate access to information in whatever correlations or summaries are useful to him.

3. To provide norms and standards extracted from thousands of case histories for use in comparing current symptoms and laboratory findings.

4. To provide access to diagnostic data indexed by symptom, preexisting condition, therapeutic actions taken, diagnosis, morbidity, or any combination of these factors.

5. To assist in planning hospitals and in determining the size and configuration of X Ray facilities, laboratory facilitie

clinics and the like through operations research and mathematical integration of the many variables involved.

6. To provide analysis of mass acreening data such as electrocardiograms or chest X Rays.

7. To provide instant access to toxicological data for use in handling industrial or domestic poisonings.

8. To provide data processing assistance in following large populations over long periods of time for studies in disease incidence or epidemiology.

9. To provide comparisons among hospitals as to disease incidence, morbidity, cost of care, length of stay by disease, and other useful indices.

10. To provide control data from the healthy patient for later use when that same patient develops a disease.

11. To provide schedules and workload analyses to reduce patient waiting time and to conserve the time of the staff.

12. To provide regional memory banks as repositories for all of the data pertinent to health or disease.

13. To provide mathematical simulation of biological systems which can assist in developing known constants, patterns, and variables in these systems.

14. To provide other as yet undiscovered indices and data to promote health and well being in future patients.

But to get back to our patient, once he is followed, treated, and released from the hospital his clinical record is transmitted to the Bureau of Medicine and Surgery to be held in computer storage until it is again required. All of the management data such as

census, cost, length of stay, type of case, and workload increments that surrounded his treatment are analyzed and recorded to become a part of the future management data available to the hospital. Meanwhile, pertinent portions of his clinical record and history can be extracted automatically and transmitted to a regional computer center specializing in research and information retrieval for that type of information. To quote a recent article that appeared in the Journal of the American Medical Association:[1]

> Medicine is extremely complicated because of the large number of interrelated variables which must be considered. Modern computers have the capacity to handle complicated analysis, store data and results of analysis, plot curves, and otherwise report results, modify data, and reanalyze, until an equation (pattern) is reached that logically accounts for the variations observed. Analysis of variance, correlation, and multiple regresion are ideally suited for such work, and computer programs are available. Because of the nature of the problems involved..... and the capabilities of modern digital computers, it would appear that the growth (probably expotential) of computer use by phisicians....... is assured.

And lest the foregoing discussion of a future hospital be discarded as sounding too much like science fiction, the reader is invited to review the following writings on the subject of hospital information systems.

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[1] Edward E. Mason, M.D., ph. D., "Computer Analysis in Development of New Diagnistic Methods," Journal of the American Medical Association., 178:11, p. 1088.

The first of these is from the jounal Circulation Research where Dr. Jordan J. Baruch discusses the present state of computer technology in hospital information systems.[1]

> It is true that the technology is such that we can state with certainty that the tasks can be done by existing systems, that they can be done with a high degree of reliability, and that they require no advances in the state of computer hardware. Many of us also feel from the limited analysis now possible that techniques exist for doing these very tasks at a lower cost than is now required for striving toward their execution. It seems safe to state, therefore, that they will be done.
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> ....
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> .....there seems little doubt that the extensibility of the computer into the fields of research, management, and medical care is limited far more by the imagination of its users than by the capabilities of the machines and programs themselves.

Doctor Baruch points out that up to 10,000 properly edited clinical records can be stored on a single reel of high density magnetic tape which would permit extremely rapid access by computer. He also points out that up to one third of a million records could be stored on ten reels of tape with access provided by a small random access disc file interconnected with a digital computer. This type of computer equipment is currently available and in daily use in industry.

Professor Robert N. Anthony of the Harvard Business School points out:[2]

> No new theories.... are required to devise (an integrated data processing system).

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[1] Baruch, op.cit.

[2] Robert N. Anthony, D.C.S., "New Frontiers in Defense Financial Management," The Federal Accountant, June 1962, p.17.

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> what is needed is time because the task is fantastically complicated. Thus the only way to proceed is to start somewhere on some piece of the system and gradually extend the pieces.

Naval hospitals have made a start with their present punched card system. With time and with the development of needs for more comprehensive systems, naval hospitals must of necessity enter the computer field in order to maintain the quality of care given their patients.

The next chapter discusses the present state of development of data processing in naval hospitals, and enumerates some of the studies being conducted.

CHAPTER II

WHERE ARE NAVAL HOSPITALS NOW?

Naval hospitals present as good an array of medical treatment facilities as the average of the civilian community; in some respects they are superior. Their furnishings have always been austere, but the quality and scope of their equipment and physical facilities has usually been superior. They experienced some difficulty attracting top grade personnel shortly after World War II, and as a result, embarked on several large scale training programs which have borne fruit in the form of superior talent available in most phases of their hospital treatment program. One of the areas where naval hospitals stand out is in the area of automatic data processing.

Beginning in 1960 with a pilot installation at the U. S. Naval Hospitals, Portsmouth, Virginia, naval hospitals have met and overcome many of the obstacles which still inhibit progress in the civilian community in data processing.

Using outmoded equipment, hampered by the conservatism of the medical profession, and slowed by lack of trained personnel, naval hospitals have managed to put together a tight, well organized, well integrated system that presently involves all hospitals and enters into the following areas of medical administration, treatment and research:

Types of Procedures Conducted

a. General Hospital Administration

Procedures in this area include the production of various schedules, directories, and rosters by automated methods to assist in operation of the hospital. Typical projects conducted in most hospitals are preparation of telephone directories, preparation of indices to hospital regulations, instructions, and notices of continuing interest to the staff, recording of automobile entry permit assignments, parking assignments, and vehicle control data for the staff, preparation of medical library bibliographic data, generation of forms and reports control data, recording of post office directory and change of address data, and preparation of automatic data processing equipment utilization data.

b. Fiscal and Supply Operations

Data processing in fiscal and supply operations covers the entire range of transactions that take place in a naval hospital. In fact, the data processing system of most hospitals was founded and justified on the basis of savings possible in fiscal and supply. The system presently consists of an integrated series of subsystems for accomplishing supplies issues, supplies cataloging, supplies receiving, supplies requisitioning, supplies inventory control, supplies funding, supplies budgeting, disposition of surpluses, purchasing, budgeting, cost accounting, fund accounting, plant property accounting, financial planning, responsibility center accounting, fund control, financial reporting, cash accounting, cash controls, military payroll preparation, civilian payroll preparation, payroll cost distribution, cost summaries, analysis

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

and reporting of fiscal data, and many other applications. Naval hospitals, incidentally, have the only completely integrated system of accrual accounting and cost based budgeting that exists in the Navy today. The fiscal and supply system derives its information from an exceptionally small number of manual source documents, and as a by product, furnishes information on such items as linen and pharmacy costs. The system has proved flexible and comprehensive enough to meet all the demands placed upon it so far. The use of automatic data processing has resulted in a considerable improvement in the quality of logistic support furnished naval hospitals.

c. Food Service Operations

Food service operations, have been confined primarily to menu production, selection, and cost control. In the existing system, the menu is prepared on a cyclical basis using standardized item inputs, and using the data processing machines to select seasonal items and to insure variation of the several entrees served each day. The patient is given a prepunched card each day with which to select his choice of entree for the next day's meal. These cards are processed, and from them flows information for provisions issues, production controls, scheduling, routing and dispatch of meals from the main kitchen, food preparation and portion controls, and many other useful items of information. Use of this system has placed the management of the food service on a firm, controlled basis in naval hospitals.

d. Plant Maintenance and Operations

The entire Navy, under the sponsorship of the Bureau of

Yards and Docks, is on a system of controlled maintenance that includes maintenance of vehicles, equipment, buildings, and improvements. The philosophy of the system is that each major maintenance project be planned, scheduled, estimated, and controlled from its inception to its completion by means of collecting workload, personnel, and materials data. The object of the system is to attain the optimum use of maintenance resources available to a command. As a byproduct, the system generates a considerable amount of useful data that must be processed, summarized, correlated and reported if the system is to be effective. Naval hospitals have designed individual data processing systems to cope with the data generated; therefore it is impractical to attempt comment on these systems generally. However, in each case the systems have been integrated with the hospital's fiscal and supply system and have generated the information necessary for adequate maintenance control.

e. Laundry Operations

The system for laundry operations concerns itself with the maintenance of the supply of linen in the hospital, and with periodic cost and inventory surveys. Data on linen costs, issues, dispositions, and inventories are maintained in a central card file. Each quarter a comprehensive physical inventory is taken and the file is updated with this information. Following the updating procedure, the file is used to record linen cost and inventory data for the preceeding quarter and to make cost and requirements projections for the next quarter. The data thus generated is of

primary value to the Nursing Service and to the management of the linen distribution system. Automatic data processing has aided materially in controlling costs and linen losses over the short while it has been in effect.

f. Staff Personnel Operations

At Present, the data processing systems in effect in staff personnel operations are somewhat fragmented, although some hospitals heve managed to integrate them into an overall personnel accounting system. The systems generally attempt to take selected items of data from personnel records and use these data repetitively for producing directories, for producing various rosters such as rosters personnel who require immunizations or who require participation in the physical fitness program, for compiling educational duty and history reports, for producing data to assist in making duty assignments, for producing training reports and school eligibility reports, for producing vocational preference reports, watch schedules and assignment lists, for producing statistical distributions of military pay for integration into the fiscal and supply system, for producing physical examination schedules, for producing special skills inventories, for producing lists of collateral duty assignments for officers, for producing rosters of members of the various boards and committees in the hospital, for producing school preferences lists, for producing analyses of performance evaluations, and for producing data for special studies of various types. The data bank represented by the punch cards containing staff personnel information has an almost infinite potential for

providing the many lists, rosters, special studies, and personnel inventories required in the day to day operation of the staff personnel function in a naval hospital.

g. Medical Service Operations

The entry of data processing into the medical service has been confined primarily to special studies. To date, such studies have included staphyloccocal infections incidence and treatment studies, statistical correlations of diagnosis with length of patient stay or with preexisting conditions, a testicular tumor study undertaken by the U.S. Naval Hospital, Newport, Rhode Island, and a study on tuberculosis incidence by the U.S. Naval Hospital, Great Lakes, Illinois. These are continuing studies and have already contributed to preparation of research papers. In addition, almost all naval hospitals are maintaining their tumor registries on punch cards. This data bank, as it increases in its coverage, shows promise of providing much valuable information on tumor incidence and morbidity.

h. Surgical Service Operations

Data processing in the Surgical Services of naval hospitals has been used extensively. Currently, data is being processed to provide information for operating room scheduling, and for correlating operations performed by diagnosis, by morbidity experienced, by length of stay, by complications, or by many other possible correlations. In addition, correlations may be made of morbidity compared with preexisting conditions, surgical risk, anesthesia used, or other possible classifications. These data

have been used to provide a daily inventory of surgical patients by location and by attending physician, to provide a cross index to medical records by type of surgical case or by diagnosis, to provide information on workload, and to provide special study information. Much of this information is cross indexed to laboratory pathology reports, to tumor histories, and to special studies being made in anesthesiology. The data serves as a basic data bank on surgical patients and can be used for many different types of correlations. One area where studies are being made is in anesthesiology. This involves the generation of data on every patient who receives anesthetic in a naval hospital. It has been in existence since early 1962 and has accumulated an enormous amount of diagnostic and morbidity data in that short time.

i. Orthopedic Service Operations

Data processing in the Orthopedic Services consist of processing essentially the same types of information as is processed for the Surgical Services. An attempt is being made to build a data bank on orthopedic case histories cross indexed to clinical records and X Ray records. The data bank provides an inventory of orthopedic patients currently under treatment, a study of hospital course and morbidity in orthopedic patients, a repository for orthopedic case history information, and an infinite variety of correlations of disease with morbidity, length of stay, results of treatment and so forth.

j. Eye, Ear, Nose, and Throat Service Operations

Data processing in the Eye, Ear, Nose, and Throat Services

of naval hospitals has been confined primarily to eye banks maintained at several of the larger hospitals. This system provides an inventory of donors and recipients, data on transplants made, and data on the history of the transplant as related to the techiques used in collecting, transplanting, and treating the patient following transplant. The volume of data in this application is small but nonetheless significant.

k. Physical Medicine Service Operations

Processing in Physical Medicine Service operations has been limited to workload and scheduling of physical medicine clinics.

l. Dental Service Operations

Dental Service applications center around workload and scheduling, but include such additional items as special studies into the use of prophylactic fluorides, and cross indexing of dental diagnosis to clinical records. The processing is limited to one or two hospitals.

m. Dependent Care

Dependent patients hospitalized in naval hospitals are included in all of the systems previously discussed. In addition, three Navy wide special studies are being made. A study of physical examination and prenatal treatment data as related to hospital course and results of delivery is being made on all obstetrical cases in naval hospitals. These records are keyed to similar records maintained on all newborn admitted to naval hospitals so that an automated record is available on all obstetric cases from the first prenatal visit through delivery and subsequent follow up of both mother and child. As many as 100 bits of

information are collected on both mother and child which allows for an almost infinite series of correlations. For example, correlation of preexisting conditions with newborn morbidity can be made or a correlation of delivery history with post natal complications is possible. In addition, a Navy wide special study is being made of gynecological malignancies under the direction of the U.S. Naval Hospital, St. Albans, New York.

m. Laboratory Service Operations

Laboratory operations provide a fertile field for automatic data processing because of the large amounts of data generated in the laboratory. Therefore, the entry of automatic data processing to the laboratories of naval hospitals has been a natural consequence of having the data processing equipment available. Systems are currently in use in cataloging and cross indexing all surgical pathology and in recording tissue bank and blood bank data. The surgical pathology application provides a cross index by type of tumor on all surgical specimens examined in the laboratory. It enables the pathologist to locate slides by type of tumor, medical records by type of tumor, and material accessioned to the Armed Forces Institute of Pathology by type of tumor. It provides other valuable correlations between preexisting conditions and tumor incidence, morbidity, and so forth. The blood bank and tissue bank applications are historical records of donors, recipients, and results achieved through transplants and transfusions. As the data increases in its coverage it will furnish many valuable correlations and studies.

n. Pharmacy Service Operations

Again, because of the large amounts of data generated, pharmacies have been a natural for automatic data processing. Currently, automated methods are being used to produce drug formularies, to control issues and custody of narcotics, alcohols and habit forming drugs, to provide workload and cost data for pharmacies, and to assist in evaluating effectiveness of drugs in use. The biggest advantages have occurred through automated production and updating of drug formularies. Using former manual methods it was a near impossible task to maintain current formulary information in hospitals.

o. Nursing Service Operations

Data processing for the nursing services has been primarily in the area of personnel scheduling, workload data integration, and workload data collection. This area has yet to be explored extensively in naval hospitals.

p. Radiology Service Operations

As with laboratory and pharmacy services, the introduction of automated methods to the radiology services has been rapid and natural. Automated methods are being used to give cross index information on X Ray examinations performed, to isolate X Ray examinations which are particularly illustrative of various disease processes, to enable special studies of disease categories, to provide scheduling and workload data on both diagnostic and therapeutic X Ray operations, to provide permanent histories of X Ray and radiation exposure, and to provide automated cross

index data to clinical records, surgical pathology records, or other records maintained on each patient. Automated processing in the radiology service has enabled hospitals to dispense with several different types of cross index files formerly maintained manually.

q. Epidemiology Service Operations

The Navy has four preventive medicine units scattered throughout the world collecting epidemiological data. These data are transmitted to naval hospitals either on a one time basis or on a continuing basis for processing and reporting. Currently, hospitals are supporting continuous research projects in respiratory disease incidence, pneumonia incidence, and incidence of heat casualties. Many other projects are being conducted on a one time basis.

n. Outpatient Service Operations

Historically, naval hospitals have been funded on the basis of inpatient treatment given. Outpatient services have been treated as a secondary part of the mission of naval hospitals until shortly after World War II when it became apparent that the importance of this type of treatment was increasing. Since that time, naval hospitals have established clinics in every medical specialty and in some subspecialties and adjunct services. Because these clinics have been decentralized, the collection of comprehensive outpatient data, workload data, scheduling information, and cost data has been cumbersome and often inexact. Also, since outpatient services are more extensive than inpatient services

in some hospitals, it has become imperative to collect accurate and complete data for funding purposes. The U.S. Naval Hospital, Jacksonville, Florida has pioneered in the development of an outpatient data system which, after several months of developmental work, has been released to the Bureau of Medicine and Surgery for subsequent modification and release to all hospitals. When this system becomes operational it is expected to produce reliable, comprehensive information on outpatient treatment for use in management, staffing, cost analysis, workload analysis, disease incidence, epidemiology, treatment profiles, and many other areas where sufficient information is not now available.

s. Various Training School and Educational Service Data

The Navy Department maintains two schools for training Hospital Corpsmen and one school for training Medical Service Corps Officers in general subjects. In addition, it maintains technical schools for both Hospital Corpsmen and Officers, and it sends many of its personnel to part time and full time training in civilian schools or schools maintained by other services. It also conducts comprehensive programs of inservice training in all medical activities for all personnel. Skills inventories, assignment data, scheduling data, evaluation data, academic performace data, and many other types of data for these programs are processed by naval hospitals to meet each hospital's specific needs.

t. Patient Affairs Data

The data processing system in patient affairs data was

introduced in January of 1963 on a Navy wide basis. It is designed to collect data on admissions, diagnoses, length of stay, morbidity, geographical area of disease incidence, and other statistics of interest. It provides summaries such as admissions by geographic area by type of disease, diagnosis by length of patient stay by morbidity encountered, census and bed availability data, information for billings and for location of next of kin, discharges by type of disposition, information on causes of accidents and poisonings, information on surgical operations performed by type of operation, and other correlations and summaries of importance. It replaces a statistical report previously prepared manually for each patient, and it replaces several statistical summaries previously submitted manually. Ultimately, it will provide a data bank containing cross index information on all patients treated as inpatients in hospitals, station hospitals, dispensaries, and ships. This type of information has proved its value in the past and automatic data processing methods make it much more accessible and useful. In order to establish the system, the Bureau of Medicine and Surgery was required to redesign almost all of the forms and records being used in collecting patient data manually and to set up each naval hospital as a regional processing center in its own geographical area for the purpose of coding and key punching data from smaller ships and stations. It is too early to forsee results of the system; however, there is no reason to believe that it will not work to the purpose intended. This

system is perhaps the most ambitious undertaking in naval hospitals aside from the fiscal and supply system. Data from this system is made available centrally at the Bureau of Medicine and Surgery as well as at each individual hospital.

u. Psychological Research

Research is currently being conducted into the circumstances and psychological profile of all recruits who experience debilitating psychiatric disturbances in recruit training, into all cases of incidence of schizophrenia, into the psychological problems associated with long periods of confinement in closed spaces such as submarines or fallout shelters, and into the psychiatric effectiveness of crews in future weapons systems. Most of this research is under the sponsorship of the National Medical Center at Bethesda, Maryland; however, some of it is being conducted at recruit training centers and hospitals.

v. Aero Space Research

Research under the sponsorship of the Naval Aviation Medical Center, Pensacola, Florida is being conducted into the physical and psychological profile of all naval aviators. In this study, each naval aviator entering flight training is examined and tested to establish control data with which to compare data collected at future intervals in the aviator's career. As the data becomes more extensive it is hoped that it will provide clues to pilot failures, and clues to better selection and training methods.

w. Neurophysiological Research

Studies in the effects of physical forces (electricity or

trauma to name two examples) on the functioning of biological systems is being conducted at the National Naval Medical Center, Bethesda, Maryland. These studies will continue to yield research data for future use.

x. Acoustics Research

This area involves processing of data primarily on high intensity noise such as that produced by jet airplanes. However, it includes other projects as well.

Types of Equipment Used

Each naval hospital has built a data processing equipment inventory to fit its own peculiar needs. As stated earlier, the equipment tends toward old, outmoded punch card equipment, but this choice has been deliberate in that those hospitals having fewer than 250 beds do not require modern equipment at this stage.

The smaller hospitals, some twelve in number, have selected the International Business Machines type 402 system as being adequate for their needs. This system is slow and has a very limited capacity for data manipulation, but it is also inexpensive and permits the use of automated methods in the smaller hospitals. The system involves the use of such peripheral equipment as card punches, card verifiers, card interpreters, sorters, reproducing punches, and calculating punches.

The larger hospitals have tended toward the UNIVAC 1004 system although three of the larger hospitals are still using

an IBM type 407 system. The UNIVAC system is a card tabulating system somewhat similar to the IBM 402 system previously described except that it incorporates the capacity for core storage of 961 characters of digital information. This gives it a configuration similar to a small scale computer; however, unlike the computer, it is programmed with a wired control panel rather than with a stored program. It is faster than many stored program computers when using card input and output, and will have the cability of being linked with a magnetic tape drive in the near future. Its core storage will permit core to core transmission of data between machines at a relatively low speed. The system requires peripheral equipment such as card punches, card verifiers, and sorters to make it effective.

The medical centers at Bethesda, Maryland and Pensacola, Florida have, in addition to their punch card equipment, an IBM type 1620 digital computer to handle the demands placed upon them by the research conducted at these locations.

Appendix B gives further details by hospital of the systems presently installed or contemplated, but as can be seen from this brief description, naval hospitals are a long way from the large scale computerized data processing system described in Chapter I. Exactly how far away, and what they must do to arrive at this system is the subject of the next chapter.

CHAPTER III

HOW CLOSE ARE NAVAL HOSPITALS

Dr. William R. Best, writing in the Journal of the American Medical Association, states that:[1]

> In years to come, I predict, computers will exert a profound influence on the practice of medicine. They will not replace the physician but they will result in a profound sharpening of his diagnostic and therapeutic abilities. Predictions regarding the number of physicians needed for the future will probably prove in error, for computers will improve the effectiveness of the individual physician. The computer will be a superconsultant with a fabulous memory and a keen ability to apply statistical methods to the problems of the individual patient. Computers are at present providing general information services to medicine and aiding in a number of research studies. In the future they will serve a key role in facilitating medical care by relieving physicians and hospital personnel of many routine tasks; by eliminating communication bottlenecks within the hospital; by assuring complete, concise, legible patient records; and by reinforcing the physicians memory and analytical abilities.

Dr. Cesar A. Caceres, in Circulation Research:[2]

> It is pertinent to think of analysis of medical data, including the diagnosis, as a result of a subjective integration of multiple variables within a physician's mind.
> ......routine computer integration of multiple data appears to be a good immediate use of machines to free the physician from part of the necessary humdrum of medicine.

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[1] William R. Best, M.D., The Potential Role of Computers in Medical Practice," Journal of the American Medical Ass'n., 182:10 p.994.

[2] Caceres, op.cit.

> Because data handling by physician and that done by a computer are similar, statistical techniques can simulate the nonlinear, multivariate analysis that physicians use in ordinary day to day work.

Here Dr. Caceres was concerned primarily with the use of computers in processing data for diagnosis. But given the proper programming, the same computers can be used for management, for information storage and retrieval, for research, for biological simulation, and for statistical analyses. In fact, it has been repeatedly demonstrated that real time data processing systems can serve as an instrument for all types of data integration in many diverse areas.

For example, the airlines have developed a real time system for recording and controlling reservations and seat availability. They are presently working on a maintenance scheduling system. Aircraft manufacturers have initiated production controls in real time, and the Bureau of Supplies and Accounts is developing a real time requisitioning system. Other industries are working on similar projects.

However, one of the prerequisites of a real time system is that it be developed on a total systems basis so that each of the parts developed is compatible with others developed previously. Only in this way can the individual pieces of the system be integrated into one overall system, for it is much too complex a task to attempt to develop the entire system at one time.

And herein lies the greatest problem in naval hospitals. Despite their progress in punched card data processing, and despite their developing capability in hospital information systems they have a long way to go. They have yet to approach the problem of hospital data processing as a total integrated system of data flow, including all parts of the hospital. Much expense and time is necessary to develop sophisticated programs for the computers; naval hospitals have yet to make a start in this direction.

A second great obstacle is to discover exactly what types of transactions take place in naval hospitals from day to day. The record here is considerably better, for a start has been made and in fact the punch card system presently in use is based upon this start, but the information must be expanded to a total systems approach.

A third obstacle is the lack of good exchange of information with other workers in the area of automated systems for hospitals. The work being done by the Veterans Administration in their pilot project in hospital systems simulation at Los Angeles[1] is one example of information that could be used, the Baylor University Medical Center study[2] is another. The National Institutes of Health program for a regional computer network,[3] or the Professional

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[1] Harold H. Wilson, "Simulated Design of a Patient Data System," Data Processing for Management, May 1963.

[2] Wertz, op.cit.

[3] "Regional Computer Centers," (editorial), The American Journal of Medicine, March 1963, p. 295.

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Activities Study at Ann Arbor, Michigan,[1] could prove extremely valuable to naval hospitals in developing their future system. In fact, the Veterans Administration study could provide finished programs and routines that would apply directly to naval hospital systems.

A fourth obstacle is the need for standardization of systems. In the beginning, each naval hospital equipped to do so was assigned several areas in the overall program and asked to develop programs and procedures in these areas that could be used by all naval hospitals. In fact, it was this approach that enabled naval hospitals to move into the data processing field as rapidly as they have.

However, the speed with which these projects were developed left some areas only partially standardized and each hospital has attempted to fill in the gaps with its own programs. This has been successful, but future integration of systems requires that all hospital programs be standardized to the greatest degree possible. Current thinking is to attempt to standardize equipment configurations in each hospital to an IBM type 402/1 system for the smaller hospitals or to a UNIVAC type 1004/C card computer for the larger hospitals, leaving the IBM 1620 digital computers for the two medical centers to support research. Following this, or proceeding concurrently if possible, completely standarized programs must be developed in all areas, by those hospitals equipped to do so.

Other problems have occurred, of which the following are examples.

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[1] Virgil N. Slee, M.D., "Automation in the Management of Hospital Records," Circulation Research, 11:3, p. 637 (1963).

There has been considerable resistance to the naval hospital data processing program though lack of knowledge of its benefits. This resistance is understandable when one considers the fact that the program has come from a system of manual data processing in 1960 to an almost complete system of automated data processing in 1963. Things have moved too fast to enable the people in hospitals to keep up with and to understand the program and its capabilities. In fact, the data processing people themselves have had trouble keeping up with it. Of course, time and education will solve most of this problem, but it may require some retrenchment in the data processing program to enable knowledge to catch up with technology.

The lack of trained personnel capable of doing the systems work associated with development of the program has been a problem. The philosophy has been to train personnel already on board, and subject to potential replacement by the data processing system, to take on the systems work and become a part of the data processing effort. This approach has worked well in most instances and has kept personnel dismissals at a minimum. But training and education of personnel in management of data processing operations is needed if naval hosputals are to retain their in-house capability.

As noted previously, there is a trend toward the UNIVAC type 1004/C card computer system in the larger hospitals. This trend can be expected to continue, and may ultimately result in a completely computerized system using equipment that is more sophisticated than the UNIVAC 1004. An interim step might be the

establishment of regional processing centers using large scale computers linked to hospitals by data transmission lines. However, ultimately, it would appear that each hospital must have its own sophisticated equipment to enable it to process its data in real time rather than after the fact as is being done at present.

Frederick E. Wertz, writing in Hospitals magazine,[1] has defined the problem which naval hospitals face. Mr. Wertz states:

> Machines of the future will result from research done today, most of which is directed and sponsored by the military establishment.

Obviously then, naval hospitals have a responsibility to provide leadership in this area of computerized systems.

The computer hardware necessary for the systems already exists. Naval hospitals have made great progress in punched card systems, but they must provide the leadership necessary to develop computerized systems.

Given continued emphasis in the area of automation of data processing, and, given a re-orientation of effort toward computers on the next few years, naval hospitals can make the hospital of 1980 seem totally obsolete by the time 1980 arrives.

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[1] Wertz, op.cit.

APPENDIX A

This appendix consists of a copy of the Cornell Medical Index-Health Questionnaire cited on page of the paper.

History Number________________

(WOMEN)

CORNELL MEDICAL INDEX

HEALTH QUESTIONNAIRE

Date________

Print Your Name ______________________________ Your Home Address ______________________________

How Old Are You? ________________ Circle If You Are . . Single, Married, Widowed, Separated, Divorced.

Circle the Highest Year You Reached In School | 1 2 3 4 5 6 7 8 | Elementary School | 1 2 3 4 | High | 1 2 3 4 | College

What Is Your Occupation? ______________________

Directions: This questionnaire is for ***WOMEN ONLY.***
If you can answer **YES** to the question asked, put a circle around the (Yes)
If you have to answer **NO** to the question asked, put a circle around the (No)
Answer all questions. If you are not sure, guess.

A

1. Do you need glasses to read? .... Yes No
2. Do you need glasses to see things at a distance? .... Yes No
3. Has your eyesight often blacked out completely? .... Yes No
4. Do your eyes continually blink or water? .... Yes No
5. Do you often have bad pains in your eyes? .... Yes No
6. Are your eyes often red or inflamed? .... Yes No
7. Are you hard of hearing? .... Yes No
8. Have you ever had a bad running ear? .... Yes No
9. Do you have constant noises in your ears? .... Yes No

B

10. Do you have to clear your throat frequently? Yes No
11. Do you often feel a choking lump in your throat? .... Yes No
12. Are you often troubled with bad spells of sneezing? .... Yes No
13. Is your nose continually stuffed up? .... Yes No
14. Do you suffer from a constantly running nose? .... Yes No
15. Have you at times had bad nose bleeds? .... Yes No
16. Do you often catch severe colds? .... Yes No
17. Do you frequently suffer from heavy chest colds? .... Yes No
18. When you catch a cold, do you always have to go to bed? .... Yes No
19. Do frequent colds keep you miserable all winter? .... Yes No
20. Do you get hay fever? .... Yes No
21. Do you suffer from asthma? .... Yes No
22. Are you troubled by constant coughing? .... Yes No
23. Have you ever coughed up blood? .... Yes No
24. Do you sometimes have severe soaking sweats at night? .... Yes No
25. Have you ever had a chronic chest condition? Yes No
26. Have you ever had T.B. (Tuberculosis)? .... Yes No
27. Did you ever live with anyone who had T.B.? Yes No

C

28. Has a doctor ever said your blood pressure was too *high?* .... Yes No
29. Has a doctor ever said your blood pressure was too *low?* .... Yes No
30. Do you have pains in the heart or chest? .... Yes No
31. Are you often bothered by thumping of the heart? .... Yes No
32. Does your heart often race like mad? .... Yes No
33. Do you often have difficulty in breathing? .... Yes No
34. Do you get out of breath long before anyone else? .... Yes No
35. Do you sometimes get out of breath just sitting still? .... Yes No
36. Are your ankles often badly swollen? .... Yes No
37. Do cold hands or feet trouble you even in hot weather? .... Yes No
38. Do you suffer from frequent cramps in your legs? .... Yes No
39. Has a doctor ever said you had heart trouble? Yes No
40. Does heart trouble run in your family? .... Yes No

OPEN TO NEXT PAGE

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D

41. Have you lost more than half your teeth? Yes No
42. Are you troubled by bleeding gums? Yes No
43. Have you often had severe toothaches? Yes No
44. Is your tongue usually badly coated? Yes No
45. Is your appetite always poor? Yes No
46. Do you usually eat sweets or other food between meals? Yes No
47. Do you always gulp your food in a hurry? Yes No
48. Do you often suffer from an upset stomach? Yes No
49. Do you usually feel bloated after eating? Yes No
50. Do you usually belch a lot after eating? Yes No
51. Are you often sick to your stomach? Yes No
52. Do you suffer from indigestion? Yes No
53. Do severe pains in the stomach often double you up? Yes No
54. Do you suffer from constant stomach trouble? Yes No
55. Does stomach trouble run in your family? Yes No
56. Has a doctor ever said you had stomach ulcers? Yes No
57. Do you suffer from frequent loose bowel movements? Yes No
58. Have you ever had severe bloody diarrhea? Yes No
59. Were you ever troubled with intestinal worms? Yes No
60. Do you constantly suffer from bad constipation? Yes No
61. Have you ever had piles (rectal hemorrhoids)? Yes No
62. Have you ever had jaundice (yellow eyes and skin)? Yes No
63. Have you ever had serious liver or gall bladder trouble? Yes No

E

64. Are your joints often painfully swollen? Yes No
65. Do your muscles and joints constantly feel stiff? Yes No
66. Do you usually have severe pains in the arms or legs? Yes No
67. Are you crippled with severe rheumatism (arthritis)? Yes No
68. Does rheumatism (arthritis) run in your family? Yes No
69. Do weak or painful feet make your life miserable? Yes No
70. Do pains in the back make it hard for you to keep up with your work? Yes No
71. Are you troubled with a serious bodily disability or deformity? Yes No

F

72. Is your skin very sensitive or tender? Yes No
73. Do cuts in your skin usually stay open a long time? Yes No
74. Does your face often get badly flushed? Yes No
75. Do you sweat a great deal even in cold weather? Yes No
76. Are you often bothered by severe itching? Yes No
77. Does your skin often break out in a rash? Yes No
78. Are you often troubled with boils? Yes No

G

79. Do you suffer badly from frequent severe headaches? Yes No
80. Does pressure or pain in the head often make life miserable? Yes No
81. Are headaches common in your family? Yes No
82. Do you have hot or cold spells? Yes No
83. Do you often have spells of severe dizziness? Yes No
84. Do you frequently feel faint? Yes No
85. Have you fainted more than twice in your life? Yes No
86. Do you have constant numbness or tingling in any part of your body? Yes N
87. Was any part of your body ever paralyzed? Yes No
88. Were you ever knocked unconscious? Yes No
89. Have you at times had a twitching of the face, head or shoulders? Yes No
90. Did you ever have a fit or convulsion (epilepsy)? Yes No
91. Has anyone in your family ever had fits or convulsions (epilepsy)? Yes No
92. Do you bite your nails badly? Yes No
93. Are you troubled by stuttering or stammering? Yes No
94. Are you a sleep walker? Yes No
95. Are you a bed wetter? Yes No
96. Were you a bed wetter between the ages of 8 and 14? Yes No

GO TO NEXT PAGE

H

97. Have your menstrual periods usually been painful? Yes No

98. Have you often felt weak or sick with your periods? Yes No

99. Have you often had to lie down when your periods came on? Yes No

100. Have you usually been tense or jumpy with your periods? Yes No

101. Have you ever had constant severe hot flashes and sweats? Yes No

102. Have you often been troubled with a vaginal discharge? Yes No

103. Do you have to get up every night and urinate? Yes No

104. During the day, do you usually have to urinate frequently? Yes No

105. Do you often have severe burning pain when you urinate? Yes No

106. Do you sometimes lose control of your bladder? Yes No

107. Has a doctor ever said you had kidney or bladder disease? Yes No

I

108. Do you often get spells of complete exhaustion or fatigue? Yes No

109. Does working tire you out completely? Yes No

110. Do you usually get up tired and exhausted in the morning? Yes No

111. Does every little effort wear you out? Yes No

112. Are you constantly too tired and exhausted even to eat? Yes No

113. Do you suffer from severe nervous exhaustion? Yes No

114. Does nervous exhaustion run in your family? Yes No

J

115. Are you frequently ill? Yes No

116. Are you frequently confined to bed by illness? Yes No

117. Are you always in poor health? Yes No

118. Are you considered a sickly person? Yes No

119. Do you come from a sickly family? Yes No

120. Do severe pains and aches make it impossible for you to do your work? Yes No

121. Do you wear yourself out worrying about your health? Yes No

122. Are you always ill and unhappy? Yes No

123. Are you constantly made miserable by poor health? Yes No

K

124. Did you ever have scarlet fever? Yes No

125. As a child, did you have rheumatic fever, growing pains or twitching of the limbs? Yes No

126. Did you ever have malaria? Yes No

127. Were you ever treated for severe anemia (thin blood)? Yes No

128. Were you ever treated for "bad blood" (venereal disease)? Yes No

129. Do you have diabetes (sugar disease)? Yes No

130. Did a doctor ever say you had a goiter (in your neck)? Yes No

131. Did a doctor ever treat you for tumor or cancer? Yes No

132. Do you suffer from any chronic disease? Yes No

133. Are you definitely *under* weight? Yes No

134. Are you definitely *over* weight? Yes No

135. Did a doctor ever say you had varicose veins (swollen veins) in your legs? Yes No

136. Did you ever have a serious operation? Yes No

137. Did you ever have a serious injury? Yes No

138. Do you often have small accidents or injuries? Yes No

L

139. Do you usually have great difficulty in falling asleep or staying asleep? Yes No

140. Do you find it impossible to take a regular rest period each day? Yes No

141. Do you find it impossible to take regular daily exercise? Yes No

142. Do you smoke more than 20 cigarettes a day? Yes No

143. Do you drink more than six cups of coffee or tea a day? Yes No

144. Do you usually take two or more alcoholic drinks a day? Yes No

TURN TO NEXT PAGE

M

145. Do you sweat or tremble a lot during examinations or questioning? .... Yes No

146. Do you get nervous and shaky when approached by a superior? .... Yes No

147. Does your work fall to pieces when the boss or a superior is watching you? .... Yes No

148. Does your thinking get completely mixed up when you have to do things quickly? .... Yes No

149. Must you do things very slowly in order to do them without mistakes? .... Yes No

150. Do you always get directions and orders wrong? .... Yes No

151. Do strange people or places make you afraid? .... Yes No

152. Are you scared to be alone when there are no friends near you? .... Yes No

153. Is it always hard for you to make up your mind? .... Yes No

154. Do you wish you always had someone at your side to advise you? .... Yes No

155. Are you considered a clumsy person? .... Yes No

156. Does it bother you to eat anywhere except in your own home? .... Yes No

N

157. Do you feel alone and sad at a party? .... Yes No

158. Do you usually feel unhappy and depressed? Yes No

159. Do you often cry? .... Yes No

160. Are you always miserable and blue? .... Yes No

161. Does life look entirely hopeless? .... Yes No

162. Do you often wish you were dead and away from it all? .... Yes No

O

163. Does worrying continually get you down? .... Yes No

164. Does worrying run in your family? .... Yes No

165. Does every little thing get on your nerves and wear you out? .... Yes No

166. Are you considered a nervous person? .... Yes No

167. Does nervousness run in your family? .... Yes No

168. Did you ever have a nervous breakdown? .... Yes No

169. Did anyone in your family ever have a nervous breakdown? .... Yes No

170. Were you ever a patient in a *mental* hospital (for your nerves)? .... Yes No

171. Was anyone in your family ever a patient in a *mental* hospital (for their nerves)? .... Yes No

P

172. Are you extremely shy or sensitive? .... Yes No

173. Do you come from a shy or sensitive family? Yes No

174. Are your feelings easily hurt? .... Yes No

175. Does criticism always upset you? .... Yes No

176. Are you considered a touchy person? .... Yes No

177. Do people usually misunderstand you? .... Yes No

Q

178. Do you have to be on your guard even with friends? .... Yes

179. Do you always do things on sudden impulse? Yes No

180. Are you easily upset or irritated? .... Yes No

181. Do you go to pieces if you don't constantly control yourself? .... Yes No

182. Do little annoyances get on your nerves and make you angry? .... Yes No

183. Does it make you angry to have anyone tell you what to do? .... Yes No

184. Do people often annoy and irritate you? .... Yes No

185. Do you flare up in anger if you can't have what you want right away? .... Yes No

186. Do you often get into a violent rage? .... Yes No

R

187. Do you often shake or tremble? .... Yes No

188. Are you constantly keyed up and jittery? .... Yes No

189. Do sudden noises make you jump or shake badly? .... Yes No

190. Do you tremble or feel weak whenever someone shouts at you? .... Yes No

191. Do you become scared at sudden movements or noises at night? .... Yes No

192. Are you often awakened out of your sleep by frightening dreams? .... Yes No

193. Do frightening thoughts keep coming back in your mind? .... Yes No

194. Do you often become suddenly scared for no good reason? .... Yes No

195. Do you often break out in a cold sweat? .... Yes No

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APPENDIX B

DESCRIPTION OF DATA PROCESSING SYSTEMS PRESENTLY INSTALLED OR CONTEMPLATED

(Equipment is listed by hospital)

U. S. Naval Hospital, Annapolis, Maryland. Annapolis has a type 870 document writer system. This is a simple data recorder with back up support furnished by the National Naval Medical Center, Bethesda, Maryland. Annapolis anticipates that it will expand to an IBM type 402/50 system sometime within the near future.

U. S. Naval Hospital and National Naval Medical Center, Bethesda, Maryland. Bethesda has a UNIVAC 1004/C system and an IBM type 1620 digital computer system installed. The UNIVAC system is, for all intents, a small scale punch card computer, while the IBM 1620 is a small scale scientific digital computer used primarily to support the research projects of the National Naval Medical Center. Both installations are located organizationally under the Medical Center but provide primary support to the hospital and activities located in the Medical Center Complex. The UNIVAC system and the IBM system are compatible.

U. S. Naval Hospital, Bremerton, Washington. Bremerton has an IBM 402/50 system installed but soon expects to go to an IBM 402/1 system because of increasing workload.

U.S. Naval Hospital, Camp Lejeune, North Carolina. The Hospital at Camp Lejeune is located on a Marine Corps station and supports some of the research being done on Marine Corps recruits. Camp Lejeune presently has an IBM type 407 system installed. In addition, a field research laboratory located at Camp Lejeune has a small analog computer installed for making temperature and cardiovascular studies in recruits. The analog computer is equipped with an analog to digital converter for maintaining a punch card output which is subsequently processed by the hospital.

U.S. Naval Hospital, Camp Pendleton, California. Camp Pendleton is also located on a Marine Corps station and supports research projects being conducted on recruits. The hospital is presently equipped with a UNIVAC type 1004/C system.

U.S. Naval Hospital, Charleston, South Carolina. Charleston is equipped with an IBM type 402/1 system. No changes are anticipated in the immediate future.

U.S. Naval Hospital, Chelsea, Massachusetts. Chelsea is equipped with a UNIVAC 1004/C system with which it supports itself as well as providing back up support to the U.S. Naval Hospitals Newport, Rhode Island and Portsmouth, New Hampshire.

U.S. Naval Hospital, Corpus Christie, Texas. The installation at Corpus Christie is not yet operational. They expect delivery and installation of an IBM type 402/50 system on 10 January 1964.

U.S. Naval Hospital, Great Lakes, Illinois. The hospital at Great Lakes supports research projects conducted by the Navy

Preventive Medicine Unit located there as well as its own projects. It presently has an IBM type 407 system installed but anticipates installation of a UNIVAC type 1004/C on 1 March 1964.

U.S. Naval Hospital, Guantanamo Bay, Cuba. The hospital at Guantanamo Bay has been overlooked for obvious reasons in the naval hospital automatic data processing program. Although they could very easily support an IBM type 402/50 system, they are presently programmed to receive only an IBM type 870 document writer system. This system will be used primarily in the patient affairs area for recording data to be processed at some other location.

U.S. Naval Hospital, Guam, Marianas Islands. The hospital at Guam is equipped with an IBM type 402/50 system. No immediate changes are anticipated.

U.S. Naval Hospital, Key West, Florida. The hospital at Key West is one of the smallest in the Navy. Initially it was planned that Key West would be supported in their data processing by the U.S. Naval Station, Key West, Florida which is located adjacent to the hospital. However, after two years of study and feasibility tests, it appears that this arrangement is not workable. Therefore, Key West is programmed to receive an IBM 402/50 installation in the near future.

U.S. Naval Hospital, Jacksonville, Florida. The hospital at Jacksonville has an IBM 402/1 system installed. No immediate changes are anticipated.

U.S. Naval Hospital, Memphis, Tennessee. The hospital at

Memphis is presently equipped with an IBM 402/50 installation. Within the near future it is planned to replace this with an IBM type 402/1 system.

U.S. Naval Hospital, Newport, Rhode Island. Originally it was planned to give the hospital at Newport an IBM type 870 document writer system and provide back up support from the U.S. Naval Hospital at Chelsea, Massachusetts. This plan proved unworkable however, and Newport has installed an IBM type 402/50 system. This system will be updated to an IBM type 402/1 system in the near future.

U.S. Naval Hospital, Oakland, California. The hospital at Oakland has one of the oldest systems in existence. It has progressed from an IBM type 402/1 system to an IBM type 407 system, and is now operating a UNIVAC type 1004/C card computer. No changes are planned for the immediate future.

U.S. Naval Hospital, Pensacola, Florida, and Naval Aviation Medical Center, Pensacola, Florida. The installation at Pensacola is located organizationally under the control of the Naval Aviation Medical Center. It supports both the Center and the Hospital as well as several smaller medical activities in the area. Because of the research demands placed on it by the Aviation Medical Center it is the second largest (second to NNMC Bethesda, Maryland) in the naval hospital program. It presently incorporates an IBM type 1620 scientific digital computer system, and an IBM type 407 system. No changes are anticipated in the near future.

U.S. Naval Hospital, Philadelphia, Pennsylvania. The hospital at Philadelphia has done a considerable amount of the program and systems work that has enabled the naval hospital automatic data processing program to move forward as rapidly as it has. Their achievements have been primarily in the area of staff personnel administration and supply operations. They are presently equipped with a UNIVAC type 1004/C card computer.

U.S. Naval Hospital, Portsmouth, New Hampshire. The hospital at Portsmouth, New Hampshire is one of the smallest in the naval hospital complex. They are equipped with an IBM type 402/50 system which should be adequate for their future needs.

U.S. Naval Hospital, Portsmouth, Virginia. The hospital at Portsmouth, Virginia acted as the pilot installation for data processing in naval hospitals beginning in early 1960. They did most of the developmental work surrounding the accrual accounting system and the civilian payroll system in use in all hospitals at the present time. They have progressed through an IBM type 402/50 system to an IBM type 402/1 system to an IBM type 407 system and, finally, to their present system which incorporates a UNIVAC type 1004/C card computer. No further changes are anticipated in the immediate future.

U.S. Naval Hospital, Quantico, Virginia. The hospital at Quantico has been slow getting started with automatic data processing for a variety of reasons. Primary among these reasons is its close proximity (60 miles) to the National Naval Medical Center at Bethesda, Maryland. At first it was planned to place Quantico under the Medical Center for data processing support and

an IBM type 870 document writer system was installed at Quantico to this end. However, this arrangement has not worked satisfactorily and Quantico is programmed to receive an IBM type 402/50 system in the near future.

U.S. Naval Hospital, San Diego, California. The hospital at San Diego is the largest in the naval hospital complex. Its bed capacity of 2000 operating beds and its heavy outpatient workload make it a prime location for a small digital computer. However, San Diego is presently doing their work with a 1004/C card computer which seems adequate for the immediate future. San Diego has been instrumental in developing the surgical data, the surgical pahology data, and the tumor registry data applications presently being used in other naval hospitals.

U.S. Naval Hospital, St. Albans, New York, The hospital at St. Albans is supported by an IBM type 407/50 system which seems adequate for the immediate future.

U.S. Naval Hospital, Yokosuka, Japan. The hospital at Yokosuka is presently supported by an IBM type 402/50 system which it is planned to update to an IBM type 402/1 system in the near future. It is interesting to note that some of the lower echelon data processing personnel at the installation are Japanese Nationals. These people were trained locally and have had very little difficulty assimilating the background knowledge necessary to accomplish their jobs effectively.

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